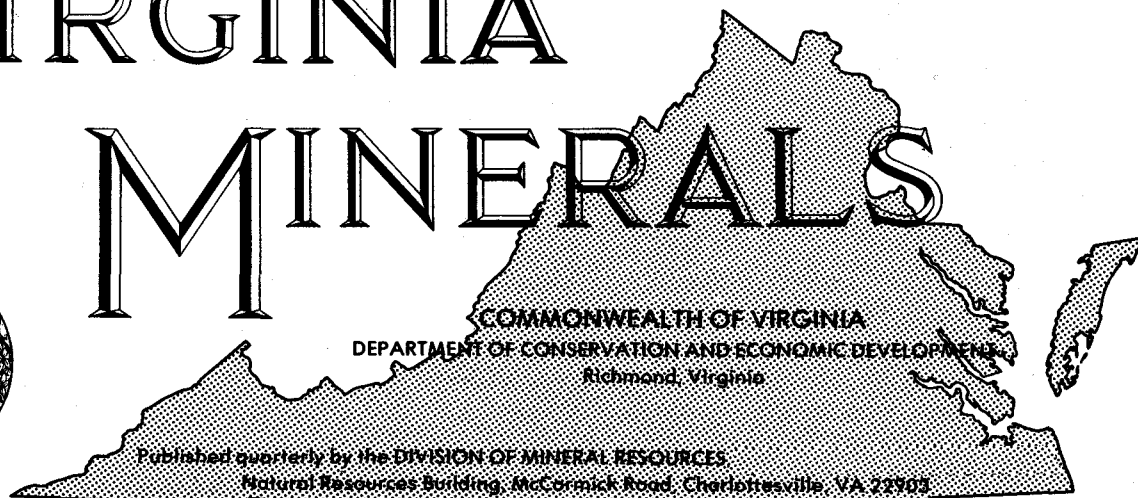


# VIRGINIA

# MINERALS



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No. 1

## NATURAL GAS IN VIRGINIA

D. C. Le Van

Natural gas is produced in Buchanan, Dickenson, Russell, Tazewell, and Wise counties in the Appalachian Plateau of southwest Virginia, and in Rockingham County in the Valley and Ridge province. In addition, gas has been produced in Scott and Washington counties, also in the Valley and Ridge area. Production of gas during 1979, entirely from the Plateau, was approximately 8.5 billion cubic feet; estimated gas reserves as of 1979 (Virginia Department of Labor and Industry, 1980) were sufficient for 13 years at the 1979 rate of production. Virginia gas is produced for both the commercial market and local use. Gas from Buchanan, Dickenson, Rockingham, and Tazewell counties is marketed commercially to major pipelines in Kentucky and West Virginia. Smaller quantities of gas are produced in Russell and Wise counties for local in-state indus-

trial use. The generalized distribution of oil and gas fields and geologic provinces in Virginia is shown in Figure 1.

A high level of interest exists among major petroleum companies and independent operators in the possibility for new gas discoveries in a large area that extends from New York southward through western Virginia to Alabama. This area is referred to by industry as the "eastern overthrust belt" because of geologic similarities to the "western overthrust belt" of the Rocky Mountains, where major discoveries of oil and gas are being made. Significant discoveries of natural gas have likewise recently been made in the eastern overthrust belt in West Virginia and Pennsylvania. The Appalachian Plateau and Valley and Ridge province of western Virginia are a part of this eastern overthrust belt. Industry has negotiated leases on much of the private and public land in western Virginia, from Lee County on the south to Frederick County on the north.

In western Virginia, production of natural gas has been developed over wide areas of the Appalachian Plateau province since 1948. Drilling of development wells and some exploratory tests continues to expand the known areas of commercial gas resources in the Plateau section. Presently known commercial occurrences of gas or oil in the Valley and Ridge province in Virginia are two gas fields, one of which is not now in production, and two small oil fields, all discovered during the period 1931-1963. Intensive exploration studies, including seismic work, are currently being done in this province

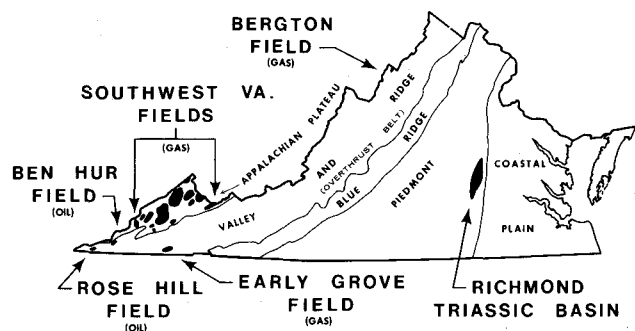


Figure 1. Generalized distribution of oil and gas fields and geologic provinces in Virginia.

by industry and government. Current geologic concepts (e.g. Harris, Harris, and Epstein, 1978) suggest that the Valley and Ridge area is chiefly a potential natural-gas province and that conditions are less favorable for large-scale petroleum reserves. It is anticipated that a number of significant wildcat wells will be drilled within the next two years to explore this prospective area of the Commonwealth. Recent seismic work suggests that the sedimentary strata of the Valley and Ridge province may extend eastward beneath crystalline rocks of the Blue Ridge and Piedmont, thereby greatly enlarging the area of interest (Harris and Bayer, 1979).

## REGIONAL EXPLORATION AND DEVELOPMENT

### APPALACHIAN PLATEAU PROVINCE

Most of the current production of natural gas in Virginia is from the Appalachian Plateau province, where approximately 500 wells have been drilled. Gas was discovered in Buchanan County in 1948, Dickenson County in 1949, Wise County in 1953, Russell County in 1955, Tazewell County in 1961, and northern Scott County in 1976. Pipeline delivery of gas from Buchanan County was begun in 1952, followed by Dickenson County in 1956 and Tazewell County in 1964.

During 1979 a total of 8,543,810,000 cubic feet of gas were produced by eight companies from 258 wells in the five currently productive Plateau counties (Virginia Department of Labor and Industry, 1980). Production has not been developed in the Plateau portions of Scott or Lee counties. During 1979 Dickenson County was the leading producer, followed in order by Buchanan and Tazewell counties. The 258 productive wells were distributed as follows: Buchanan 130; Dickenson 106; Russell 1; Tazewell 19; Wise 2. The leading producing company was Columbia Gas Transmission Corporation with 122 gas wells, followed by Philadelphia Oil Company with 68 wells, Ashland Exploration, Inc. with 36 wells, and 5 other companies with 13 or fewer wells (Virginia Department of Labor and Industry, 1980). Annual gas production from Buchanan, Dickenson, and Tazewell counties is shown graphically in Figures 2, 3, and 4.

The gas occurs principally in the Greenbrier Limestone ("Big Lime") and the Berea and other sandstones of Mississippian age, and in Devonian shale at depths that range from approximately 3500 to 6000 feet. The regional stratigraphy of gas-bearing Mississippian rocks in southwest Virginia and adjacent states has been described by Wilpolt

and Marden (1959) and more recently by DeWitt, Cohee, and McGrew (1979) and Englund (1979).

Present drilling in the Plateau province is chiefly focused upon filling in and extending areas of present gas production in the formations that are now productive. The possibilities for production from older strata below presently developed zones remain to be evaluated by additional deep drilling in the area. The Devonian shale section is gas-bearing over a wide range of the Appalachian Basin, and, as

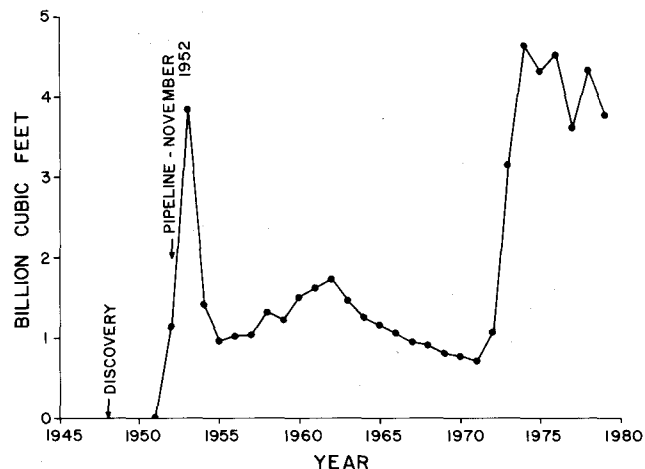


Figure 2. Annual gas production from Buchanan County. Data for 1955-79 from issues of Annual Report published by Virginia Department of Labor and Industry. Data for 1948-54 from unpublished information in Division files.

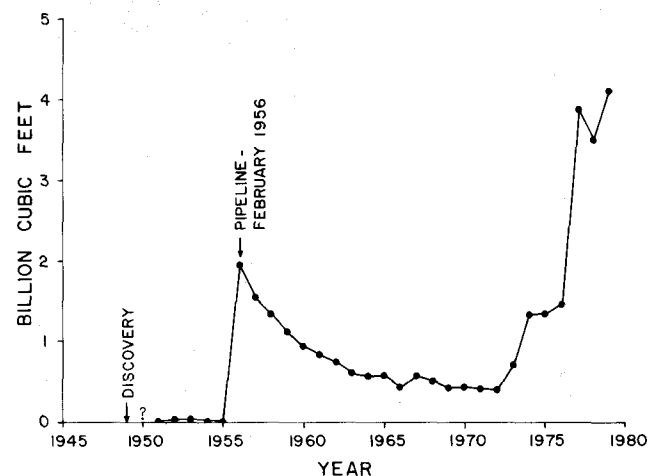


Figure 3. Annual gas production from Dickenson County. Data for 1955-79 from issues of Annual Report published by Virginia Department of Labor and Industry. Data for 1949-54 from unpublished information in Division files.

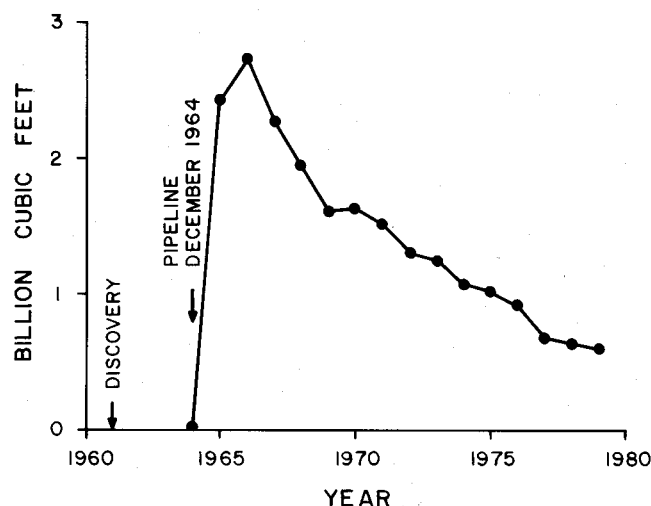


Figure 4. Annual gas production from Tazewell County. Data from issues of Annual Report published by Virginia Department of Labor and Industry.

noted, supplies some gas in the Plateau province of Virginia. The shale represents a large potential source of gas. Maximum utilization of this resource appears dependent upon development of appropriate techniques for siting wells in favorable fracture zones and for artificial stimulation of the gas yields into wells. Detailed studies have been made by numerous research groups as a part of the Eastern Gas Shales Program, sponsored by the U.S. Department of Energy, and by the petroleum industry. Methane associated with coal beds in the Plateau also constitutes a potential resource. Lack of appropriate technology and legal questions concerning ownership of the methane have hindered development of this possible source of gas.

#### VALLEY AND RIDGE PROVINCE

As a part of the exploratory effort in the eastern overthrust belt, major oil companies and independent operators are conducting extensive geological and geophysical work in the Virginia portion (an area of about 10,000 square miles) of the Valley and Ridge province. This area is underlain by strata of Cambrian to Mississippian age that have been complexly folded and are cut by major eastward-dipping thrust faults. Potential exploration targets in this province include anticlines, ramps, and other fault-associated structures, and stratigraphic traps. Gas has been produced commercially from two fields located by early exploration activity and gas shows have been encountered during drilling at other localities.

*Early Grove Gas Field:* The first commercial gas discovery in Virginia was made in 1931 in the Valley and Ridge province. The discovery well was drilled on the axis of the Early Grove anticline in Scott County. This test well found gas that was gauged at 1,750,000 cubic feet per day in sandy zones of the Little Valley Limestone of Mississippian age at depths between 3212 and 3272 feet. Additional wells were drilled on this structure in Scott and adjacent Washington counties and gas production was developed from this formation. Gas was also found in Devonian shale in this field and some gas was reportedly produced (Huddle, Jacobsen, and Williamson, 1956). Gas from the Early Grove field was supplied to the city of Bristol by a small-diameter pipeline from 1938 until about 1958 when the field was abandoned. Annual production from the field is shown in Figure 5. The cumulative

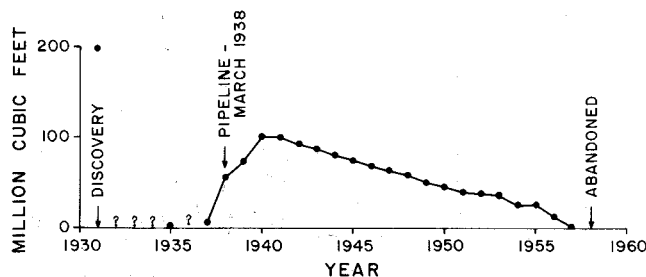


Figure 5. Annual gas production from the Early Grove gas field. Data for 1955-58 from issues of Annual Report published by Virginia Department of Labor and Industry. Data for 1941-54 from unpublished information in Division files; 1931-40 from Averitt (1941).

yield of gas to 1958, as totalled from various sources, is believed to have been about 1.3 billion cubic feet. A deep test drilled near the discovery well in 1963-64 encountered gas in the Clinch Sandstone (Silurian), which was measured at the rate of 103,000 cubic feet per day; the hole was plugged back and completed as a shut-in gas well in the Little Valley Limestone. A well drilled in this field in early 1980 reportedly found natural gas in the Price Formation of Mississippian age. Additional wells have been drilled during 1980 in an attempt to re-establish production from the field.

A wildcat well drilled in 1915 about two miles northeast of the present Early Grove field encountered a small pocket of gas which caught fire and burned the rig (Averitt, 1941). No further information is available for this well, which was drilled to a depth of approximately 2500 feet.

The geology and early development of the Early Grove field were described by Averitt (1941) who reported analyses of the gas as follows:

Sample from discovery well		
methane	97.89 percent	
ethane	1.57 percent	
butane	.14 percent	
pentane	—	
propane	—	
nitrogen	.40 percent	
carbon dioxide	0.00 percent	
oxygen	0.00 percent	
moisture	none	
Composite sample from all wells		
Btu at 760 mm and 60°F	1028.5	
S.G. at 760 mm and 60°F (air = 1)	.563	

*Bergton Gas Field:* In the Valley and Ridge province, gas has also been found in northern Rockingham County on the Bergton-Crab Run anticline. The gas occurs here in the Ridgeley (Oriskany) Sandstone of Devonian age. Drilling began in the Bergton area in the 1930's and between 1951 and 1956 five gas wells were completed at depths of about 2985 to 3800 feet. Although some gas was used for local purposes, commercial production was not established until 1980 when a small-diameter pipeline was built by James F. Scott Oil and Gas to deliver gas from two of the wells to a major transmission line in West Virginia. New wells drilled in the Bergton field in 1980 have found additional gas and a second local line has been built by Merrill Natural Resources, Inc., to connect with the West Virginia pipeline. The geology and early exploration in the Bergton area were described by Young and Harnsberger (1955) who cite two analyses of the gas as follows:

<b>A</b>		
methane	98.69 percent	
ethane	0.12 percent	
propane	0.01 percent	
nitrogen	1.18 percent	
carbon dioxide	0.00 percent	
Thv. Btu/cu ft.	987	
Sat. 30 ins. Hg, 60°F		
S.G. (air = 1)	0.5604	

<b>B</b>		
methane	97.1 percent	
ethane	1.3 percent	
propane	—	
nitrogen	1.1 percent	
carbon dioxide	0.3 percent	
oxygen	0.2 percent	
Thv. in Btu/cu ft.	997	

*Other Areas:* Natural gas has been encountered during drilling at other localities in the Valley and Ridge area. In Lee County, Miller and Fuller (1954) report that a well drilled about two miles west of the Rose Hill oil field hit a flow of 225,000 cubic feet per day in the basal sandstone of the Cayuga dolomite (Silurian), and cite an analysis of the gas as follows:

methane	89.2 percent
nitrogen	2.7 percent
ethane	5.1 percent
propane	1.8 percent
butane	0.8 percent
Btu (saturated with water)	1024
Btu (dry)	1042

Another well in Lee County, about six miles northeast of the Rose Hill field, was reported (Miller and Brosgé, 1954) to have encountered a flow of gas from the Reedsville Shale (Ordovician) estimated at 100,000 cubic feet per day. Shows of gas were encountered in Ordovician and Cambrian rocks in a deep test drilled about a mile southeast of the Rose Hill field (Harris, 1967). In the Ben Hur oil field, also in Lee County, a well drilled in 1967 encountered a blowout of gas which caught fire while drilling was in progress in the Trenton Limestone (Ordovician). The gas flow into the hole was followed by oil and the well was subsequently completed as an oil well. Other gas occurrences reported by operators include an estimated flow of 50,000 cubic feet per day from the Martinsburg Formation (Ordovician) in Montgomery County and "less than 100,000" cubic feet per day after treatment of Ordovician rocks in a well in Russell County. Devonian shales that are widespread in the Valley and Ridge province have potential as sources of unconventional natural gas, as noted in the discussion of the Appalachian Plateau. Methane that may be associated with coal beds in the Valley coal fields is also a possible energy resource.

Recent evolution of geologic thought concerning the Valley and Ridge province is providing a better understanding of the potential for oil and gas. The geologic structure and hydrocarbon potential along major thrust faults in southwestern Virginia have been discussed in a recent publication of the Division of Mineral Resources (Bartholomew and others, 1980). The relationship of regional structure to areas of oil and gas production has been described by Harris and Milici (1977) and Milici (1980). Rader and Perry (1976) and Perry, Harris, and Harris (1979) present re-interpretations of geologic structures in the Valley and Ridge area and discuss the implications for hydrocarbon occurrence.

### BLUE RIDGE AND PIEDMONT PROVINCES

The Precambrian and Paleozoic crystalline rocks of the Blue Ridge and Piedmont are not appropriate environments for occurrences of oil and gas, and industry has traditionally regarded such areas as having no potential. Recent seismic and geologic data from various parts of the Appalachian area are interpreted by some (e.g. Harris and Bayer, 1979) to indicate that some Blue Ridge and Piedmont rocks may have been thrust westward for a distance of at least 100 miles and that sedimentary strata continuous with those of the Valley and Ridge province may be present at depths of 5,000 to 10,000 feet beneath them. A press release issued by the U.S. Geological Survey in October 1979 suggested that this concept may double the area of interest for natural-gas exploration in the Appalachian Mountains from Virginia to Alabama. Predictions concerning the nature of the inferred sequence of buried sedimentary strata have been made by Dennison (1980). Debate exists among various researchers as to whether gas or oil may have formed or been preserved in these strata. If suitable economic incentives and exploration techniques are developed, test wells may be drilled in Virginia to evaluate the potential of these postulated deep strata.

Approximately 15 wells are known to have been drilled in sedimentary rocks of the Richmond, Culpeper, and Farmville Triassic basins in the Piedmont. Shows of oil were reported in some of these tests, most of which were drilled during the period 1910-1945, but their validity is unknown as no further information is available. There is current interest by several groups in the possibility of producing the methane that may be associated with coal beds in the Richmond Basin, and some leasing and test drilling has been done in that area.

### COASTAL PLAIN PROVINCE AND CONTINENTAL SHELF

A few oil and gas tests have been drilled on the Coastal Plain in Virginia but no significant shows were encountered. Federal leases have been issued in several areas on the Outer Continental Shelf off the Mid-Atlantic states as a result of OCS Sale Number 40 in August 1976 and Sale Number 49 in February 1979. Gas-bearing zones and some oil have been found in wells drilled on OCS leases off New Jersey in the Baltimore Canyon trough, which approximately parallels the coast from New York to North Carolina. Further drilling is being done to evaluate the feasibility of commercial production in that area. The potential for hydrocarbon resources in the Baltimore Canyon trough has been discussed

by Benson (1979). A discussion of the stratigraphy and depositional environments in the trough was presented by Poag (1979).

No drilling has taken place in waters off the Virginia coast where one tract, about 70 miles east of the Eastern Shore Peninsula, is under lease. A third sale of Federal offshore leases in the Mid-Atlantic area, Sale Number 59, is tentatively scheduled for December 1981. Tracts proposed for leasing in Sale 59 extend farther south and seaward than those leased in Sales 40 and 49 and include acreage off Virginia.

### STATE NATURAL-GAS PRODUCTION

State production of natural gas for the years 1931-79 and drilling activity for the years 1955-79 are shown graphically in Figures 6 and 7. Virginia gas production for the years 1931-51, as shown in Figure 6, represents the limited output of the Early

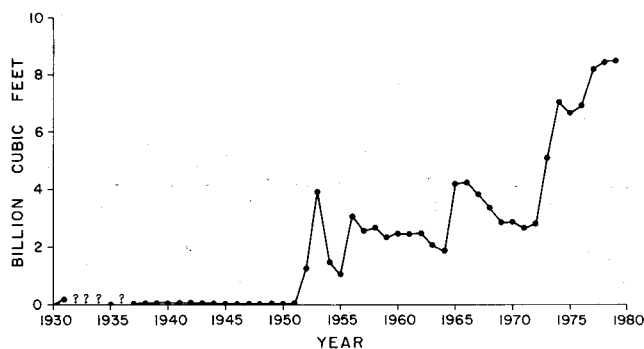


Figure 6. Virginia gas production for the years 1931-79. Data for 1955-79 from issues of Annual Report published by Virginia Department of Labor and Industry; 1931-54 from unpublished information in Division files.

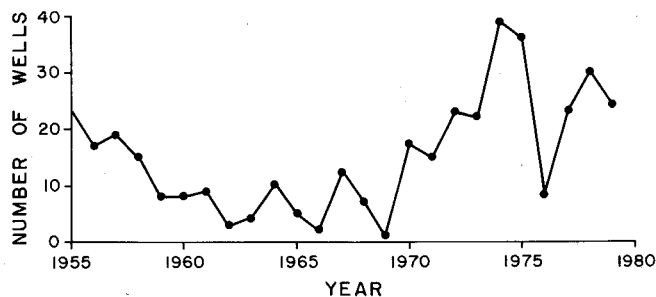


Figure 7. Drilling activity in Virginia for the years 1955-79. Data from issues of Annual Report of Virginia Department of Labor and Industry.

Grove field in Scott and Washington counties, following discovery in 1931. The large increase in State production commencing in 1952 coincides with the establishment of pipeline deliveries of gas from the Appalachian Plateau area of southwestern Virginia, where initial discovery was made in 1948, to a transmission line in West Virginia. The increased production for 1973 and subsequent years reflects a renewal of drilling effort in the Plateau area beginning in 1970, as shown in Figure 7, and the establishment of more-extensive, local gathering facilities. In 1979 there were 24 new test wells drilled in the State for oil and gas, of which 15 were completed as gas wells (Virginia Dept. of Labor and Industry, 1980). Total State remaining reserves of natural gas as of December 31, 1979 are reported by the State Oil and Gas Inspector (Fulmer, 1980) to be 111,027,374,000 cubic feet.

### LEASING

A highly competitive leasing effort has been carried on in the Commonwealth by major companies and independents during recent years. A comparison of productive and nonproductive acreage under lease for oil and gas in Virginia and nearby states, as of January 1, 1979, is shown in Table 1. At that time

Table 1. Estimated productive and nonproductive acreage under lease for oil and gas as of January 1, 1979 (from *Petroleum Information Package*, July 1, 1980, Exxon Company, U.S.A., p. 56).

	Total Land Area of State (Acres)	Total Land under Lease (Acres)	Percent of Total Land under Lease (Acres)
Virginia	25,459,200	1,205,866	4.7
Kentucky	25,376,000	3,925,000	15.5
Maryland	6,330,240	285,900	4.5
Pennsylvania	28,778,240	16,133,360	56.1
Tennessee	26,449,920	3,333,335	12.6
West Virginia	15,404,800	12,972,000	84.2

about 1,205,866 acres, or 4.7 percent of the land area of the State, were under lease in Virginia. By the end of 1979 a total of 2,023,745 acres had been leased, and by September 1980 the total leased acreage had increased to between 2,750,000 and 3,000,000 acres, about 11 percent of the State, as reported by the State Oil and Gas Inspector. This leasing activity has been concentrated in the area west of the Blue Ridge and extends the length of the

State from Frederick County to Lee County. Some leasing has recently taken place in the Blue Ridge and westernmost Piedmont areas of central Virginia; this activity is apparently based on the postulated eastward extension of sedimentary Valley and Ridge strata beneath the crystalline rocks of the Blue Ridge. Leases have also been acquired in the Richmond Triassic Basin of the Piedmont, chiefly for the methane resources that may be present in coal beds in the area.

Both private and Federal lands have been leased extensively. There is no requirement for a standard lease form on privately-owned land in Virginia. Such oil and gas leases are subject to negotiation between the landowner and the company seeking to lease the land. Typical leases now current in western Virginia may provide, for example, for a bonus of from one to five dollars or more per acre upon execution of the lease, annual rentals of one dollar per acre, a royalty on one-eighth to the landowner from any production that may be established, and a term of five to ten years.

Applications for oil and gas leases in the George Washington National Forest totalled approximately 561,000 acres and in the Jefferson National Forest 455,000 acres as of May 1980. Leases in the National Forests are issued initially on a first-applicant basis by the Federal Government for a ten-year term unless dropped sooner or held by production. The leases carry annual rentals of one dollar per acre and provide for a one-eighth royalty to the Federal Government.

The petroleum industry has also expressed interest in leasing State-owned lands in Virginia. Tracts owned by the State are administered by various agencies and include such diverse categories as State Forests, State Parks, lands of the Commission of Game and Inland Fisheries, university lands, and submerged lands. A variety of mineral-right reservations and deed restrictions exist on some of these lands. There is no uniform policy regarding oil and gas exploration and leasing on State lands and the subject is currently undergoing review.

### PRICE OF NATURAL GAS

The average wellhead value of natural gas produced in Virginia during 1979 was reported to be \$1.68 per thousand cubic feet (Virginia Dept. of Labor and Industry, 1980). Wellhead values for natural gas in Virginia for the years 1947-1979 are shown in Figure 8. The rapid price increase that began in the mid - 1970's, together with the evolution of geologic concepts and the potential for an energy crisis, are providing new incentive for exploration for natural gas in Virginia.

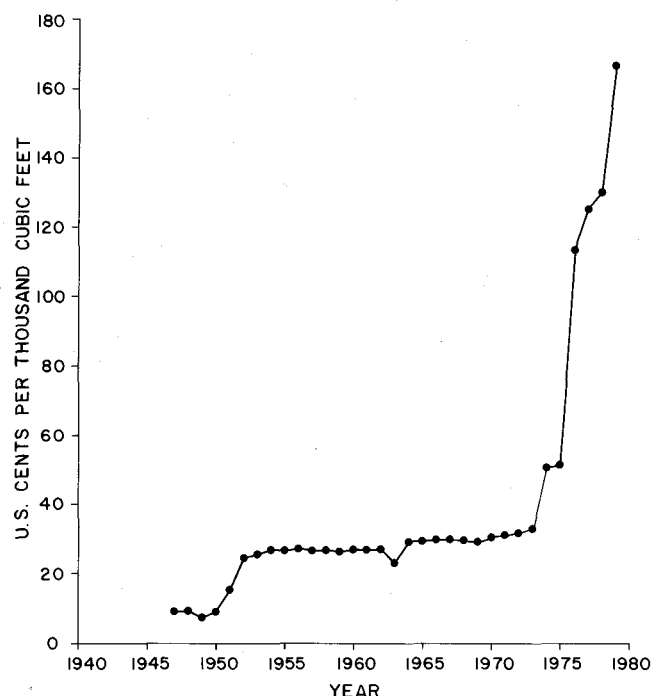


Figure 8. Average annual wellhead prices of Virginia natural gas 1947-79. Information for 1947-78 from American Petroleum Institute (1977 and update) and for 1979 from Virginia Department of Labor and Industry (1980).

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## STAFF CHANGES

William F. Giannini of Scottsville, Virginia joined the permanent staff of the Division of Mineral Resources on August 1, 1980. Mr. Giannini, who received his M.S. in geology from the University of Virginia in 1959, was employed previously by the Flintkote Company at Stephens City, Virginia. He is in the Economic Section of the Division and is currently conducting a State-wide carbonate study. He is married and has a daughter.

Joseph J. Arnold of Hershey, Pennsylvania joined the permanent staff at the Division on August 18, 1980. Mr. Arnold received a B.S. degree in geology from the University of Miami in 1957 and a M.S. degree in geology from the University of Arkansas in 1960. His work experience includes nearly 20 years of employment in private industry and state government. Mr. Arnold is in the Economic Section where he is working on oil and gas, industrial minerals, metallics, and coal resources.

## NEW EDUCATIONAL SECTION

Have you been reading "Outdoor Classroom" in the school issues of *Virginia Wildlife* magazine? The new section is especially designed for teachers and students. Included are articles about animals, insects, birds, fish, plants, the ocean, teaching aids, activities, interesting places in Virginia, and of course, geology!

All schools in Virginia should be receiving special copies of the Virginia Commission of Game and Inland Fisheries' monthly magazine during the school year. If your school is not getting its copy, please contact Mr. Harry Gillam, Editor, *Virginia Wildlife*, Virginia Commission of Game and Inland Fisheries, Box 11104, Richmond, Virginia 23230.